THE MEASUREMENT OF INFORMATION INTEGRITY

Arguing that there never was a time when politicians did not prevaricate and when some communities did not doubt conclusions that others considered to be facts, *The Measurement of Information Integrity* puts the post-truth era in context and offers measures for integrity in the modern world.

Incorporating international examples from a range of disciplines, this book provides the reader with tools that will help them to evaluate public statements – especially ones involving the sciences and scholarship. It also provides intellectual tools to those who must assess potential violations of public or academic integrity. Many of these tools involve measurement mechanisms, ways of putting cases into context, and a recognition that few cases are simple black-and-white violations. Demonstrating that a binary approach to judging research integrity fails to recognise the complexity of the environment, Seadle highlights that even flawed discoveries may still contain value. Finally, the book reminds its reader that research integrity takes different forms in different disciplines and that each one needs separate consideration, even if the general principles remain the same for all.

The Measurement of Information Integrity will help those who want to do research well, as well as those who must ascertain whether results have failed to meet the standards of the community. It will be of particular interest to researchers and students engaged in the study of library and information science.

Michael Seadle was long the Director of the Berlin School of Library and Information Science, Humboldt-Universität zu Berlin, Germany, and Dean of Humanities. His current research areas include information integrity and digital archiving, and he currently serves as Executive Director of the international iSchools organisation.

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PREFACE

Context

The year 2020 was unusual because of the sheer quantity of information integrity topics. Three major events helped to shape the information landscape for the European and North American public. One event was the election of Donald Trump as the US President in 2016 and his defeat in 2020. A second was the COVID pandemic throughout the world, and particularly in the US and Europe, resulting in a disproportionately high number of deaths in some countries. The third event was the British departure from the European Union (Brexit), and the subsequent negotiations. Other salient events included the crash of the Boeing 737 Max in 2019, which resulted in an unusual amount of information about how respected corporations may cover up their own bad judgment, and the ongoing development of the Retraction Watch Database as scholars rushed to bring out pandemic-related articles, a number of which had to be retracted by prestigious journals because of fatal flaws.

No one should read this book as a history of the year 2020, but the year plays a role because it demonstrated the importance of having intellectual and technical tools to measure the integrity of information as a basis for making informed judgments about conflicting claims. In a different year the examples might have been different, but the need for measurement would have remained the same. Calculating the overall quantity of misinformation in 2020 is not a goal of this book. Not only would that task be enormous, but the experience of Retraction Watch has shown that a systematic categorisation of information integrity violations based on journal retraction notices is complicated enough, and adding up all possible forms would be like calculating all the possible shades of grey in a black-and-white photograph. This grayscale metaphor is relevant at multiple levels throughout this book, because information integrity issues are never so simple as black or white, right or wrong, true or false. A grayscale range almost always plays a role and is precisely what makes measurement processes important, because all of the nuances of error and accuracy play an important role in how we can understand the information landscape in which we live.

The year is not the only context issue that plays a role in the structure of this book. Location, language, cultural background and preferred news sources all influence the selection of issues and examples. An author who believed in QAnon or in other conspiracy theories would likely have picked different sources and have come to quite different conclusions, even while still talking about measurement. Measurement is itself a tool, and the output from any measurement process will very much depend on the information inputs that are fed into it. This book draws heavily from the Retraction Watch Database, from the *New York Times*, the *Guardian*, and the public German news programme ARD. A feature that all of the sources have in common is their respect for the scientific method and for the results that come from scholarly investigation. Measurement itself is an integral part of how science is done in the modern world. What is new here is the attempt to apply measurement techniques to information integrity itself.

How to read this book

There are two obvious ways to read this book. It was written from start to finish, chapter after chapter, over a period of about seven months, and reading it from start to finish is the ideal approach to have a sense of how the ideas developed and interact. It is not a story with a historical beginning or ending. The first chapters set the social and institutional context, the middle chapters discuss measurement techniques and examples, and the final chapters look at how the actors involved with discovering and judging information integrity make use of the tools and techniques from earlier chapters.

An alternative way to read the book is primarily for people who are seeking specific kinds of information or techniques. For example, those readers whose primary interest is in how the various scholarly disciplines compare with each other in terms of retractions due to problems with plagiarism, data falsification, image manipulation, unreliable data, or analysis problems can go directly to Chapter 4 on "Disciplines," which uses the Retraction Watch Database to provide a rich set of detail, including comparisons from discipline to discipline.

Readers with a special interest in guidelines should look first at Chapter 3 on "Context and institutions," which discusses the complex landscape of institutional, agency, and national rules, which often say the same thing in different words, and which are generally so abstract that students seriously interested in avoiding problems may have no clear idea about what to do after reading them. These rules are written at a high level of abstraction for a good reason: no rule-making body has the technical expertise to cover every situation that might arise, especially as scientific approaches evolve over time.

Readers who want to learn measurement techniques that they can apply on their own may want first to look at Chapter 5 on "Measurement," which takes the reader through the core issues of classification and categorisation, without which there is no basis for the kind of counting that is at the heart of measurement techniques. The chapter also looks as concrete examples of where measurement has played a role with issues of public interest.

Reasers who care in particular about how humans interact with information integrity cases and violations can begin with Chapter 6 on "Actors," which discusses four categories: investigators (who are sometimes called hunters and who look for violations), judges (who must decide on the validity of accusations and assign penalties, when appropriate), violators (the people who commit integrity breaches, either intentionally or unwittingly), and victims (who may be those who suffer from the consequences of false information, but may under some circumstances also be the violators themselves).

The conclusion, Chapter 7, attempts to pull together many of these themes, but is by no means a substitute for reading what has gone before.

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1

INTRODUCTION AND APPROACH

Introduction

Untruths, exaggerations and outright lies have all existed as long as humans have communicated with each other. The problem today is not merely that a great deal of fake or false information influences people on life-and-death issues such as the ongoing COVID-19 pandemic, but that people need tools for distinguishing between factual information that meets demonstrable standards for reliability and claims that may seem attractive or plausible but lack demonstrable reliability and pose risks. Individual listeners or readers may judge on the basis of personal factors such as tone or style, or a preference for particular outcomes, or on any number of other subjective factors, Subjective factors represent an efficient mental shortcut compared to analysing every statement, and everyone uses them. Nonetheless, as J.R.R. Tolkien (1961) famously wrote, "Shortcuts make long delays," and delays can be fatal. Sometimes tools are needed to cut through the brambles to find the right path, and this book is about measurement tools that can help to determine the integrity of information.

Information is an essential commodity in human society and arguably has been important ever since the first humanoid species learned how to pass on techniques for hunting, gathering, making fire and making tools. In a complex society information directly or indirectly governs everything that people make and do. The very process of writing and publishing a book like this builds on centuries of experience with the development of language, writing, printing as well as the intellectual development of the structure of a book with chapters, references, indexes and headings. The ability to read it depends on information transmitted during the educational process.

In May 2020 when work on this book began, one of the key information problems was how soon the COVID-19 pandemic's rate of replication would have slowed sufficiently to allow more people to return to their workplaces. The measure of the replication rate is called R_0 which is "an epidemiologic metric used to describe the contagiousness or transmissibility of infectious agents" (Delamater et al., 2019). The R_0measure has a life-and-death aspect, because the more a pandemic spreads, the more people die. But the longer people are kept from their workplaces, the more a national economy suffers, which affects the quality of life and has indirect life and death aspects too, depending on the local social safety net. The quality and integrity of the information that scientists use to make these decisions needs to be correct beyond any reasonable doubt.

This book will look at all aspects of the integrity of information in public discourse and in scholarly works. Scholarly works matter especially because they stand at the

core of any well-informed public discourse. Without the reliability of scientific information, the public discourse degenerates easily into the equivalent of a shouting match where facts fail and the biggest, loudest, and most insistent voice wins. With reliable information, lawmakers and national leaders have at least a reasonable chance of making the best possible decisions in the interests of their citizens, but explaining the science can still be challenging. The German Chancellor Angela Merkel, herself a trained scientist, made a public broadcast explaining why social distancing can save lives:

> Merkel's explanation of the scientific basis behind her government's lockdown exit strategy, a clip of which has been shared thousands of times on social media, had all the calm confidence expected of a former research scientist with a doctorate in quantum chemistry...
>
> *(Oltermann, 2020)*

Bhalla (2020) of Vox News claimed that the broadcast went "viral."

Relatively few countries have trained scientists in their leadership, which makes it important that the quality of information that reaches citizens is as reliable as possible. Nothing can guarantee that citizens or national leaders will listen to high-quality information, but some effort can be made to measure whether false or misleading information is labelled appropriately, especially when it risks lives.

A note on vocabulary

The words "science" and "scientist" appear frequently in this book, and these terms have somewhat different shades of meaning in modern English, German, and French. Contemporary English often uses the word "science" as meaning "natural science," while the meaning of the German word *Wissenschaft* or the French term *la science* embraces the social sciences and humanities as well. When this book uses the word *science* in its broader continental European sense, it will be put in italics to distinguish it from the more limited meaning that applies only to the natural sciences.

The phrase "information integrity" needs clarification as well. In this book it serves as an umbrella term that includes both ends of the scale, from the negative (such as "information fraud," "fake information" and "false information") to the positive (such as "reliable information"). This book generally avoids simple abstract dichotomies like "lies" or "truth" to emphasise the degree to which information integrity represents a broad continuum and not merely the extremes.

Problem statement

The problem statement that this work addresses is simple: *to what degree can measurement and the tools involving measurement assist in determining the integrity of information, both in the context of public discourse and in academic research*.

As the problem statement implies, there is no simple answer to most cases involving the integrity of information. Often broad grey-zones exist between reliable *science* as we currently understand it and an overly simplistic untruth that contradicts known facts. The grey-zone metaphor comes from digital photography and is meant to give readers a visual sense of range between the pure whiteness of "truth" and the pure blackness of "lies." While few scholars believe that integrity is a simple black-and-

white matter; public announcements about the results of integrity investigations often err in a black-or-white direction to make a point, because serious discussion about integrity problems quickly becomes too complex to make good headlines.

This book focuses on an intellectual tool called "measurement" that has existed at least as long as lies have existed. At one level the word "measurement" is simple. It can mean the number of grams (or ounces) of a particular ingredient in a recipe, or the number kilometres (or miles) to the nearest store, but even at this level the word measurement shows its inherent complexity. Grams and ounces have precise meanings in modern times, as do kilometres and miles. The older terms such as ounces and miles grew out of traditional usage that varied from place to place and did not necessarily require absolute precision for every purpose. The metric measurements came from the reforms during the French Revolution and had precise international values from the start, which made them attractive for engineering and natural science applications. Precision in measurement depends in part on the details of categories and classification. A simple example is the distance from one building to another, which depends on whether the measurement starts at a particular door or the nearest outer wall or in some countries from parking lot to parking lot.

Counting

Counting is an essential element of measurement, and counting is also ancient. The earliest clay tablets from Mesopotamia contained accounting records that included the numbers of animals someone owned. The British Domesday Book represented a count of people and property in the newly conquered Norman possessions. Such counts represent essential social and economic tools from ancient times onward, especially for taxation. Counting was not always precise and sometimes had legal quirks. For example, Article 1, Section 2, Clause 3 of the US constitution before the US Civil War included a rule that counted slaves as only three fifths of a person for determining congressional representation. Definitions matter and affect the accuracy of the measurement.

Reliable measurements of many aspects of society became common in the nineteenth century. By 1820, France, Prussia, the UK and the US all had some form of census with a range of questions that variously asked about social and economic status as well as collecting simple population numbers to determine representation in legislative assemblies. The data were not perfect, but were sufficiently reliable for the needs of the time. Regional, state, and municipal governments also began gathering social and economic data on a more frequent basis.

Karl Marx spent long hours in the British library gathering statistics about the social conditions of the working class for his books and manifestos. In the later nineteenth and early twentieth centuries Sidney and Beatrice Webb became famous for their use of official British records to support their arguments for "Fabian socialism." The British records were largely truthful, if not always comprehensive. When the Webbs travelled to the Soviet Union in the 1930s and applied the same techniques using government records, they mistakenly believed that Soviet records were equally reliable. The book that resulted from these records, *Soviet Communism: A New Civilization?* (Webb, 1935), proved to be an embarrassment, because the Soviet data were politically skewed to the point of untruth. Without reliable data, measurement fails and the results become meaningless.

Statistics

One of the important mathematical tools for measurement is statistics. At one time the word statistics primarily meant data, and what is today called descriptive statistics sticks closely to the original meaning with minimal abstraction in its counts, percentages, graphs and other forms of visualisations. Inferential statistics uses mathematical logic expressed in rigorous theorems as the basis for tests that draw conclusions with a degree of mathematical probability. Inferential statistics uses mathematical logic expressed in rigorous theorems as a basis for evaluating how likely observed sample data would be, if a given hypothesis is true. For example, when researchers testing a new medication report $p < 0.05$, it means that if the medication is in fact useless, at least nineteen samples out of twenty of the size and characteristics the researchers have used would indicate uselessness. (If $p < 0.01$, then at least 99 samples out of a hundred would indicate the medication is useless.)

The reliability of the claim depends also on a wide variety of factors, including the degree to which a sample accurately reflects the population being studied, the quality (reliability) of the data in the sample, and how the so-called "null hypothesis" was stated because that is what is being tested. Statistics is a sophisticated and highly complex science that is integral to a wide range of disciplines. The fact that statistical results rely on assumptions about data and their distribution does not mean that statistical results are flawed or unreliable, only that a reader needs to understand what they mean in order to interpret the results correctly.

Statistics can be highly misleading if the samples were skewed to produce a particular result. The mere existence of numbers does guarantee that any serious measurement took place or that the results are correct. Fake news often provides statistics that lack integrity. Goodwin (2020) writes:

> Faced with arguments underpinned by numbers, we need to cultivate statistical alertness so we can spot the falsehoods but also read authentic statistics with shrewdness... Common sense should be our first line of defence.

One of Goodwin's examples was a survey that the *Daily Express* published in 2015 that "showed 80% of Britons wanted to quit the EU." The survey had a low response rate and a self-selection problem.

Reliable statistics play important roles in business, and the insurance industry offers a classic example. Most western countries keep reliable records about death rates including the age at death and the causes of death. An actuarial analysis of, for example, a non-smoking middle class male with no history of cardiovascular illness suggests statistically that he is likely to live longer than a poor male smoker with a history of heart trouble. While the conclusion may seem obvious, the important question for insurance companies is how much greater is the likelihood of an early death, which will in turn affect the pricing for insurance coverage. This form of measurement provides a rational basis for the pricing, but of course it works only if the information an applicant provides on the forms is true. An actuarial analysis also provides a tool for judging claims that do not fit the model, such as a 40 year old male smoker applicant with known cardiovascular problems who claims that family members with a similar profile always live to 90. Such individual cases could be true, but the statistical likelihood may be low, except in cases where new drugs or certain kinds of lifestyles may make a difference. The point is that statistical analysis is not

simple, but that it can provide a logical basis for establishing the plausibility of unlikely claims.

A pandemic like COVID-19 affects all forms of data about death rates, and thus changes the expectations on which insurance and many other medical businesses depend. The year 2020 experienced many models about replication rates, death rates, and the likelihood that certain members of society are more at risk (older men, for example) than others. It is a clear instance where separating probable truth from potential false claims takes on life-and-death importance. The pandemic has functioned almost like an experiment in which the different countries have played out different experimental conditions for handling the infection and death rates. Over time it will become clearer whether countries that put a priority on lives via social distancing, extensive testing and medical care fare better economically in the long run than countries that made choices to keep the economy functioning at the expense of additional deaths. While a pandemic might affect everyone equally, the current evidence suggests that the poor and old die at higher rates than working age middle class people. An unpleasantly cruel choice could be to let the poor and the old die because their deaths free society from the burden of caring for them longer in old age and thus benefits the economy as a result. No leader has ever admitted to wanting that, though some appear to have preferred it. That is, however, an ethical question, and this book is about measurement, not ethics.

Other tools

Measurement is certainly not the only tool for judging the integrity of information, but other tools often build on the data from measurement. One example is the model that the blog Fivethirtyeight uses for predicting election results. Nate Silver (2020) describes this model in detail, both in terms of the polls that get included and other factors such as demographic and economic data and an "uncertainty index":

> When it comes to simulating the election – we're running 40,000 simulations each time the model is updated – the model first picks two random numbers to reflect national drift (how much the national forecast could change) and national Election Day error (how off our final forecast of the national popular vote could be)...

One old and standard tool for judging information quality is its source. The reasoning is that if the source is known to be reliable, the information is likely to be reliable too. For example, it is generally reasonable to believe statements about medical issues by a person with a medical degree from a respectable university who specialises in the disease being discussed and who has years of experience. During the COVID-19 crisis people generally trusted the advice of specialists like Dr. Anthony Fauci, director of the US National Institute of Allergy and Infectious Diseases. Like Dr. Fauci, a good expert may give warnings and complex answers that do not serve the goals of the political leadership, which makes it hard for political leaders to accept his advice. Ignoring expertise can, however, be dangerous in the longer term.

Accepting the advice of experts like Dr. Fauci is to some extent a cultural issue. Germany has a longstanding respect for learning and technical expertise: many federal and local cabinet members have doctorates, and a person with an academic credential is generally accepted as a reliable source. Other countries such as Japan and Korea share this tendency. In contrast, people in the US and the UK often express scepticism

about academic expertise. The idea of "muddling through" (UK) or self-reliance (US) leaves people sceptical about claims that academics know more. Members of some churches and religious sects would rather trust the statements of their pastors or leaders than outside specialists. For them the pastor or leader is the source with the highest reliability because that person speaks the word of God. Measurement plays no role there.

A problem with relying too heavily on any single source is that the source could include hidden assumptions that undermine any simple claims. By and large statistics from government agencies in western democracies are considered reliable, but problems may emerge when looking beneath the surface. For example, the state COVID-19 death rate in Florida was under dispute. The *Miami Herald* reported: "The health department is also excluding some snowbirds and other seasonal residents, along with visitors who died in Florida, from its count. The medical examiners are including anyone who died in Florida" (McGrory and Woolington, 2020). In some sense both ways of reporting could be true and reasonable, but excluding seasonal residents served a local political purpose of reducing the state's death count. The problem had other ramifications, since the Florida out-of-state deaths appear never to have been reported to people's home states, meaning that their counts were also under-reported.

The problem is that putting trust in even official sources is itself not automatically reliable, except in cases where the sources are highly regulated and carefully defined, and even then the nature of the regulation and the meaning of the definition need to be transparent. Historians have grappled over the centuries with the problem of which sources to trust. Many historical sources have reflected the bias or blindness of past eras, and people need to be no less willing to question the authority of sources in the contemporary world. The quality of a source itself needs measurement to determine the degree to which it should be trusted. This does not mean that all sources should be distrusted, only that sources themselves need to be measured using critical judgment to examine what they really say, as examples in later chapters will demonstrate. The process is far from perfect, but a willingness to examine details brings readers one step closer to something like the truth.

Ethics

Many books on information integrity put a strong focus on ethics, and it is almost impossible not to encounter ethical considerations when writing on the subject. A trained philosopher might reasonably argue that many aspects of measurement have ethical components, since measurements involve choices about what is worth measuring. Ethical considerations are too important to ignore completely, but the focus of this book will remain on the technical and scholarly aspects of how to measure, what to measure, and what the results can tell about the degree to which an information integrity violation has occurred. Ethical analysis by itself cannot expose the facts about whether an integrity violation has occurred, only how to react to an ethical violation. The methodological approach, which the next chapter will discuss, emphasises how people understand and apply the mechanisms of measurement.

No analysis is of course ethically neutral, as will become clear when talking about those whose job it is to hunt and to judge violations. The focus of this book is, however, not on the ethics for hunting or judging per se, but on mechanisms for evaluating the results. This book offers tools that anyone can use in judging information integrity

issues, including those who commit violations.

Methodology

This book's methodology is fundamentally the methodology of a trained historian (which the author is). Academic history uses a very wide set of disciplines to gather data, including economics, political science, and in more recent times ethnography and computing. The means of collecting the data is not the defining aspect of historical methodology as much as the ways of looking at the data, which typically emphasise factors such as change over time and the temporal and social context. Historical sources are often but not exclusively text-based. Traditionally historians draw on published works and archival sources. Such sources are often "open access" in the sense that others could visit archives and read published works in libraries. Some sources are of course harder to find than others and some archives and libraries are not completely open to the public. The sources in this work are almost all available to other researchers and in most cases are freely available on the internet. One reason is because the writing has taken place during multiple COVID-19 shutdowns when libraries were at least partly closed and travel was limited. Another reason is to provide maximum transparency for the sources.

One dilemma that typically confronts the historian is how much to reference and what to treat as general knowledge. What seems like general knowledge to a historian may not be general knowledge for the general reader. The reference to the French Revolution in the section above has, for example, no external reference because the author has a reasonable expectation that readers know about it. There is also no reference to the definition of the gram and metre, even though these may not be universally known, because it is general information easily found in encyclopedias including Wikipedia. The importance of an element of information plays a role in the use of references. The definition of the gram and metre were used as examples, but statistics about, for example, COVID-19 deaths will of course be referenced.

Not all quotations will be from original English language sources. The author will generally make the translation himself from German, French, and other western European languages. The original can be found in a footnote for multilingual readers.

Trust

One of the methodological questions that a historian must consider is which sources to use when writing about trust and the integrity of data. The usual rule is that peer-reviewed articles and books have a high measure of trust, but that is clearly too simplistic in a discussion of cases where exactly such works are under examination for possible integrity violations. Retraction Watch (retractionwatch.com) is a source that dates from 2010 and reports on a wide range of article retractions in peer-reviewed sources. Retraction Watch belongs to the Center for Scientific Integrity, which "is a 501(c)3 non-profit. Its work has been funded by generous grants from the John D. and Catherine T. MacArthur Foundation, the Laura and John Arnold Foundation, and the Leona M. and Harry B. Helmsley Trust." (Retraction Watch, n.d.)

The reputation of Retraction Watch is relatively high among scholars, except of course among those whom Retraction Watch targets. An example of such criticism comes from Teixeira da Silva (2016): "Retraction Watch is a distinctly anti-science blog

whose primary objective is to smear scientists who hold errors or retractions to their names." In fact the reporting (in blog format) focuses primarily on factual information about retractions from academic journals, and the sources are almost always transparently available.

Integrity issues are highly sensitive in the scholarly world because they affect reputations and future prospects. In political discourse it is relatively common to accuse opponents of false statements with little or no evidence. Many listeners and readers automatically discount such claims, but the question becomes more problematic when health issues are at stake. The anti-vaccine campaign was built on a now retracted study of 12 children by Wakefield et al. (1998) that linked Autism with a vaccine for measles, mumps and rubella. The reasons for the anti-vaccine campaign appear to have less to do with medical science or with the Wakefield paper than with personal beliefs and a private distrust in science, at least according to a 2017 WHO pamphlet called "How to Respond to Vocal Vaccine Deniers in Public." The debate can take on an almost religious dimension that sounds like a clash of fundamental beliefs. While this clash is real, the real issue ought not to be one of belief, but of the evidence that the scientific method offers. Facts matter.

It is of course not enough to trust the mere claim of a researcher or scholar that a result is based on solid scientific evidence. The claim also needs a transparent grounding in reproducible facts. In chemistry this may mean mixing two reagents together in the same strength under the exact same conditions and getting the same result. In economics it may mean running the same analysis against the same data for the same result. For historians and other humanities scholars proof is more complicated and means going to the same sources in the same context. The interpretations of the words or economic analysis or chemical results may vary, but the underlying facts should remain. Take away those facts and the basis for trust is gone. A reader of Retraction Watch may legitimately believe, as da Silva wrote, that its objective is to smear scientists, but the retraction notices in the journals are there for anyone to see. The facts remain, despite disagreement about their meaning, and integrity thrives on the measurable existence of facts.

Time

Truth is not timeless. Creation stories were credited as facts in pre-modern times because they had become integrated into people's thinking over hundreds, even thousands, of years, and the very existence of the world seemed like something that needed a story to explain it. Before Copernicus it seemed like a reasonable fact that the sun and planets orbited the earth, since people could easily observe the sun and moon and planets rising and setting. The facts of the movements remained when Copernicus offered a new mathematical explanation based on the earth rotating around the sun. His advantage was that he offered a solution that was mathematically simpler and more reliable, and that had economic benefits for navigation. In a sense Einstein's general relativity turned the tables again by allowing any point (even an accelerating body) to serve as the central point for making observations and taking measurements. This did not mean that Ptolomy was right and Copernicus wrong, only that both were mathematically reasonable representations of the world. In schools children still learn that the earth rotates around the sun. It works as a fact, even though over time scientists have learned to express the meaning more cautiously.


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